

E 1.28: SOLAR / 1024 - 79 / 03

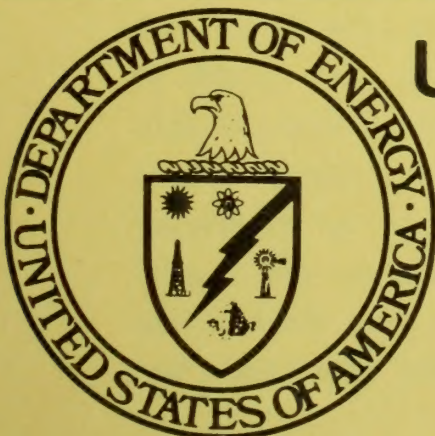
Aleph 1214299

SOLAR/1024-79/03

Monthly Performance Report

LIVING SYSTEMS

MARCH 1979



U.S. Department of Energy

National Solar Heating and
Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT

LIVING SYSTEMS

MARCH 1979

I. SYSTEM DESCRIPTION

The Living Systems site is a single-family residence in Davis, California. The home has approximately 1700 square feet of conditioned space. The solar energy system consists of two independently controlled systems: an active system for preheating domestic-hot-water (DHW) and a passive system for space heating the home.

The active solar DHW system has an array of flat-plate collectors with a gross area of 46 square feet. The array faces south at an angle of 45 degrees to the horizontal. Potable city water is the transfer medium used throughout the system. In the event of freezing and no insolation, the controller drains the water from the collectors. When water in the collector is sufficiently warmer than the water in the preheat storage tank, the controller starts the circulation between the preheat tank and the collector. The preheat tank holds 82 gallons of water which is supplied, on demand, to a conventional 20-gallon DHW tank. When the water preheated by solar energy is not hot enough to satisfy the hot water load, a natural gas burner in the DHW tank provides auxiliary energy for water heating. The system is shown schematically in Figure 1.

The passive solar space heating system is of the direct-gain type illustrated schematically in Figure 2. Incident solar energy is admitted to the building through both the large south-facing vertical windows (approximately 200 square feet) and the overhead skylight (approximately 80 square feet at 60 degrees from the horizontal). Manually-operated insulating curtains provide insulation during the night and sunless days for the south-facing collector windows. Manually-operated insulating shutters also provide night insulation for the skylight glazing and are aluminum coated to provide reflection to the space below when open. Solar energy is stored in steel tubes that contain approximately 3600 gallons of water. The tubes are painted blue and placed near the south window wall and under the skylight. Additional

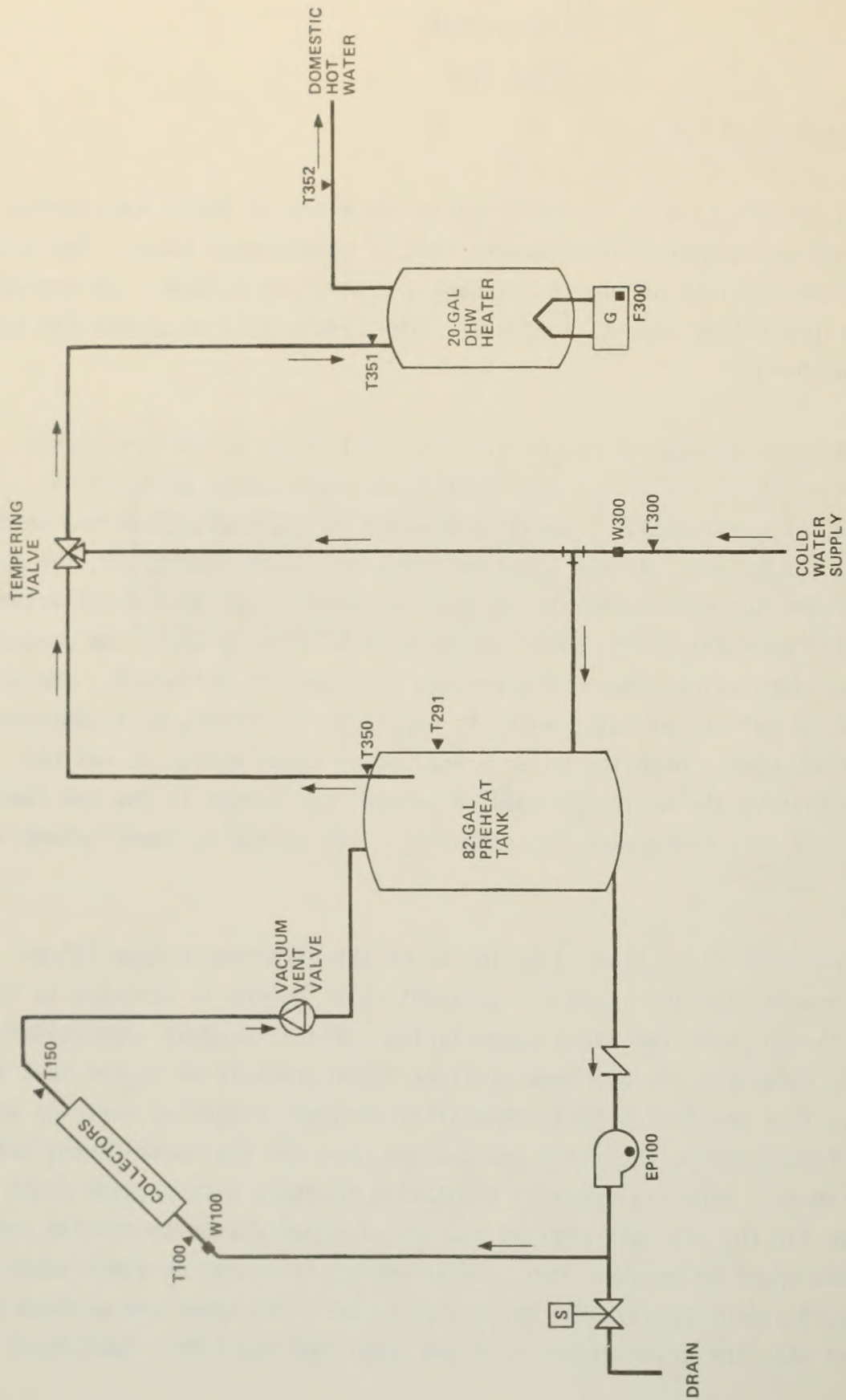


Figure 1. LIVING SYSTEMS ACTIVE SOLAR DOMESTIC HOT WATER SYSTEM SCHEMATIC

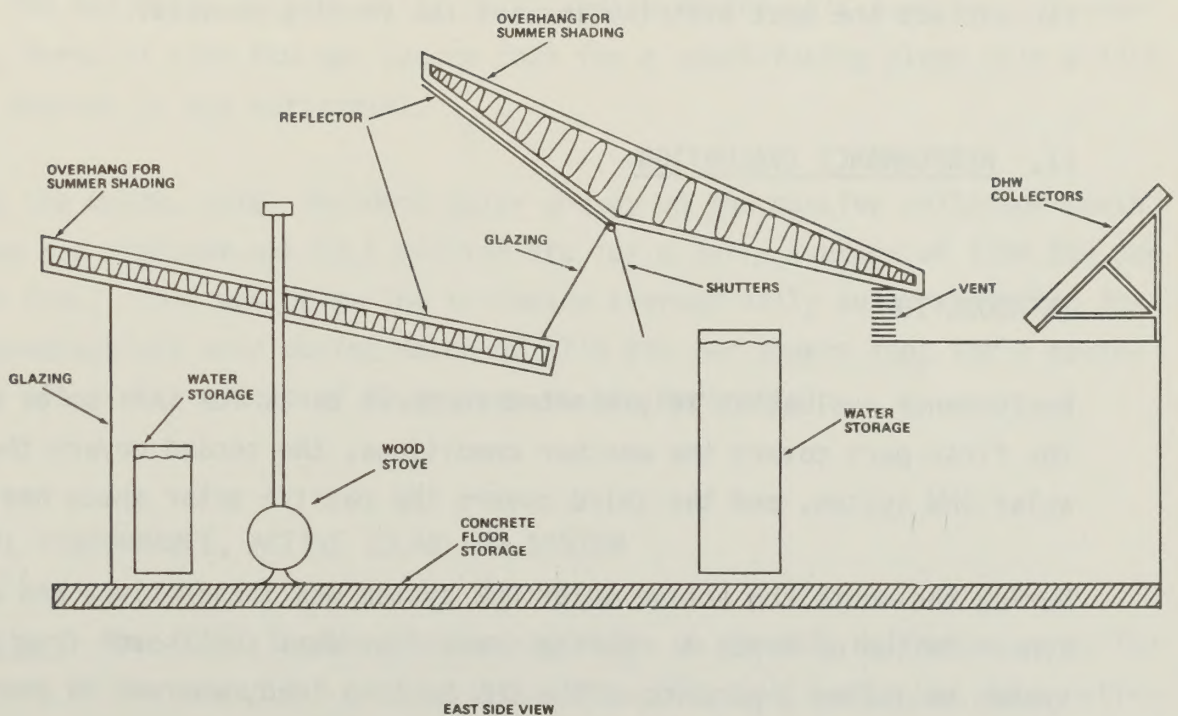
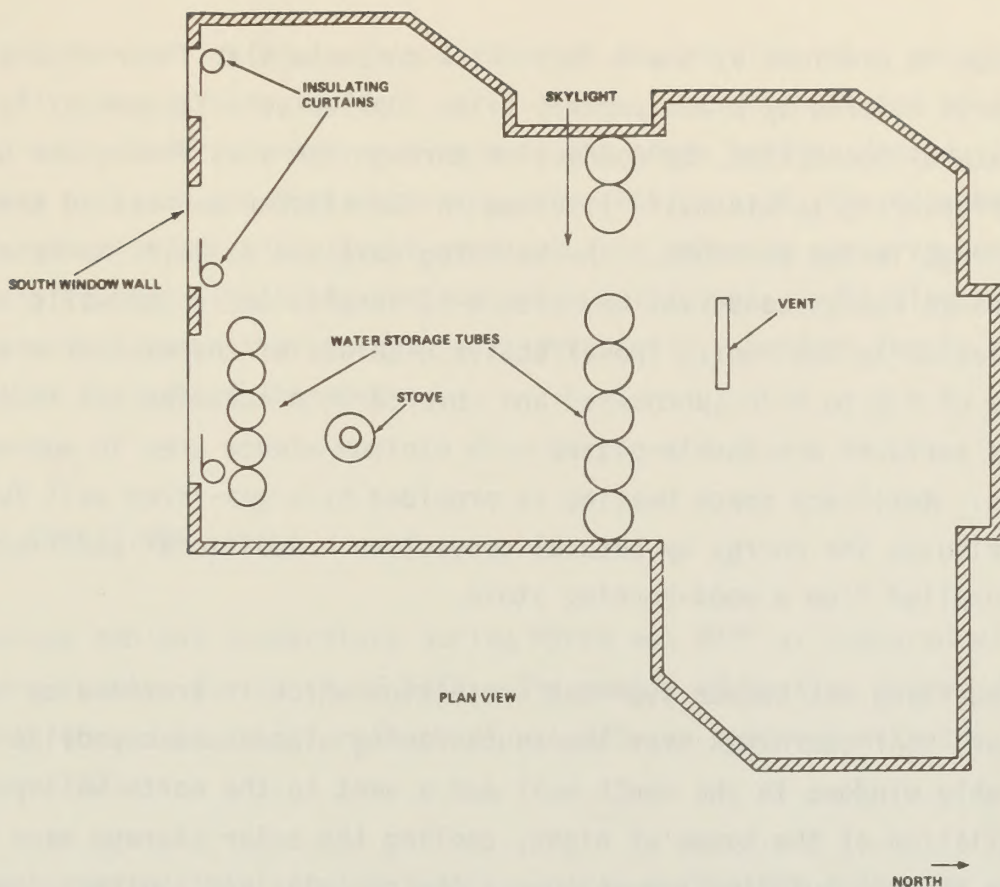


Figure 2. LIVING SYSTEMS PASSIVE SPACE HEATING SYSTEM

storage is provided by the 6-inch-thick concrete slab floor of the building which is covered by brown ceramic tile. Collected solar energy is distributed by natural convection, by conduction through the slab floor, and by radiation. Floor covering is minimal: linoleum in the kitchen and eating area and white shag rugs in two bedrooms. The building envelope is well insulated in order to ensure energy conservation, with R-19 insulation in the walls and R-30 insulation in the roof. The effective R-values of the windows are in the range of R-2 to R-10 (uncovered and covered with curtains and shutters). All glass surfaces are double-glazed with minimum window area in nonsouth-facing walls. Auxiliary space heating is provided by a gas-fired wall furnace which distributes the energy by natural convection. Additional auxiliary energy can be supplied from a wood-burning stove.

The building has summer overheat protection which is provided by several means: Roof overhangs over the south-facing glazed areas provide shading; operable windows in the south wall and a vent in the north wall provide cross-ventilation of the house at night, cooling the solar storage mass and moderating daytime building temperatures; the curtains and shutters over the windows prevent collection of incident solar energy during the day; and a ceiling fan assists the heat distribution and the venting process.

II. PERFORMANCE EVALUATION

INTRODUCTION

Performance evaluation is presented in three parts for this solar energy site: The first part covers the weather conditions, the second covers the active solar DHW system, and the third covers the passive solar space heating system.

During the month the active solar DHW system was inoperative, and a critical sensor failed on March 4. During these four days spill-over from the passive system satisfied 3 percent of the DHW heating load, whereas 99 percent of the

monthly space heating load was satisfied by the passive solar energy system. During five days of low incident solar energy, operation of the wood-burning stove provided backup energy and reduced the space heating demand. Since auxiliary heat had not been necessary since February 18, the occupants turned off the space-heater pilot light on March 3 in order to conserve energy. Daily variations in building temperature were minimal, indicating the presence of substantial amounts of energy storage capacity. Comfort levels remained reasonable throughout the month.

WEATHER CONDITIONS

The average ambient temperature during March was 54°F as compared with the long-term average for March of 53°F. The number of heating degree-days for the month (based on a 65°F reference) was 343, as compared with the long-term average of 372.

During the month, total incident solar energy on the DHW collector array was 1.8 million Btu for a daily average of 1295 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during March of 1798 Btu per square foot for a south-facing plane with a tilt of 45 degrees to the horizontal.

During the month, total incident solar energy on the passive collector south windows and skylight was 10.1 million Btu for a daily average of 1194 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during March of 1718 Btu per square foot for a south-facing plane with a tilt of 60 degrees to the horizontal.

THERMAL PERFORMANCE, ACTIVE SOLAR DHW SYSTEM

Collector - The total incident solar radiation on the DHW collector array for the month of March was 1.8 million Btu. The collector system was inoperative due to freeze damage December 8. However, while the collectors were inoperative,

the storage, pipes, sensors, etc. were still working. There was leakage of 0.049 million Btu from the passive heating system into the DHW preheat system. The fuel sensor failed on March 4, but for the first four days the effective solar fraction was 3 percent, based on four days usage. There was no operating energy required by the inoperative collector loop.

DHW Load - The DHW system consumed 0.049 million Btu of solar energy. The hot water load was 1.7 million Btu. The passive system spill-over resulted in fossil fuel energy savings of 0.082 million Btu. A daily average of 116 gallons of DHW was consumed at an average temperature of 123°F delivered from the tank.

THERMAL PERFORMANCE, PASSIVE SOLAR SPACE HEATING SYSTEM

The total incident solar radiation on the collector windows for the month of March was 10.1 million Btu. The total solar energy collected was 4.1 million Btu. The total amount of solar energy delivered to the space heating load was 4.0 million Btu, resulting in a collector array efficiency of 40 percent, based on total incident insolation. Auxiliary thermal energy of 0.020 million Btu (equivalent to 0.087 million Btu of auxiliary fossil fuel energy) was added to satisfy a space heating load of 4.0 million Btu. This includes three days of pilot light losses that were not applied to the load. The result was a fossil fuel energy savings of 6.7 million Btu. The solar fraction of this load was 99 percent. The average storage temperature for the month was 68°F.

On five days in March, the wood-burning stove was used to satisfy a small amount of the building load. The thermal energy derived from operation of the wood-burning stove is applied as a reduction to the building load; that is, the major difference between the building load and the space heating system demand is the energy derived from operating the wood stove. During March, this renewable energy was approximately 0.24 million Btu. Assuming a wood-stove energy conversion efficiency of 30 percent, this 0.24 million Btu is approximately equivalent to 3 percent of a cord of dry hardwood (such as

oak). In terms of the savings of nonrenewable energy, the renewable thermal energy derived from the wood is equivalent to 0.40 million Btu of fossil fuel energy.

The interior comfort level was measured at 68°F in both zone 1, the south end of the building, and zone 2, the north end.

OBSERVATIONS

During the month of March, the home owner was well adjusted to living in the passive home. The wood-burning stove was used for at least part of five days of the month. With the space heating load reduced by milder weather, operation of the reflective (and insulating) shutters and curtains was not as critical and the operational to incident solar energy went down. The curtains are still not fully operational. With reasonably large uncurtained windows in the northeast bedroom, some afternoon overheating has been observed. The DHW system was inoperative, but significant preheating occurred from leakage into the pipes and storage from the passive system.

Computed temperature comfort levels inside the building were reasonable during the entire month in both zones of the building, varying at most by 2°F on any given day. Except when the home was at its warmest (73°F), the comfort level in zone 2 was slightly lower than that of zone 1. This was due to the method of transferring heat to zone 2 (with zone 1 being the primary collection and storage area of the house).

ENERGY SAVINGS

The solar energy system yielded a total fossil fuel energy savings of 6.8 million Btu. The DHW system provided an estimated fossil fuel energy savings of 0.082 million Btu. The space heating system contributed a fossil fuel energy savings of 6.7 million Btu.

III. ACTION STATUS

Repair of the active solar DHW system is under negotiation by the home owner. The fuel-metering system on the DHW heater has to be repaired by Boeing.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT SITE SUMMARY

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA
REPORT PERIOD: MARCH, 1979

SOLAR/1046-79/03

SITE/SYSTEM DESCRIPTION:

THE LIVING SYSTEMS SOLAR DOMESTIC HOT WATER SYSTEM PROVIDES PREHEAT TO THE BUILDING DOMESTIC HOT WATER SYSTEM. THIS ACTIVE SYSTEM USES FLAT PLATE COLLECTORS (46 SQ.FT.) TO HEAT WATER DIRECTLY IN A 82 GALLON STORAGE TANK. AUXILIARY HOT WATER ENERGY IS PROVIDED BY NATURAL GAS IN THE 20 GALLON HOT WATER HEATER.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	1.846	MILLION BTU
COLLECTED SOLAR ENERGY	40137	BTU/SQ.FT.
	0.000	MILLION BTU
	0	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	54	DEGREES F
AVERAGE BUILDING TEMPERATURE	67	DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.03	
ECSS OPERATING ENERGY	0.000	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.000	MILLION BTU
TOTAL ENERGY CONSUMED	*	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	1.675	N.A.	N.A.	1.675
SOLAR FRACTION	*	N.A.	N.A.	*
SOLAR ENERGY USED	0.049	N.A.	N.A.	0.049
OPERATING ENERGY	N.A.	N.A.	N.A.	0.000
AUX. THERMAL FUEL	*	N.A.	N.A.	*
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A.
AUX. FOSSIL FUEL	*	N.A.	N.A.	*
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	0.000
FOSSIL SAVINGS	0.082	N.A.	N.A.	0.082

SYSTEM PERFORMANCE FACTOR:

*

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978,
SOLAR/0004-78/18

MONTHLY REPORT
SITE SUMMARY

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA
REPORT PERICC: MARCH, 1979

SITE/SYSTEM DESCRIPTION: THE LIVING SYSTEMS SOLAR TO THE BUILDING DOMESTIC HOT WATER SYSTEM. THIS ACTIVE SYSTEM USES FLAT PLATE COLLECTORS (46 SQ. FT.) TO HEAT WATER DIRECTLY IN A 82 GALLON STORAGE TANK. AUXILIARY HOT WATER ENERGY IS PROVIDED BY NATURAL GAS IN THE 20 GALLON HOT WATER HEATER.

GENERAL SITE DATA:	
INCIDENT SOLAR ENERGY	1.948 GIGA JOULES
	455792 KJ/SQ.M.
COLLECTED SOLAR ENERGY	0.000 GIGA JOULES
	0 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	12 DEGREES C
AVERAGE BUILDING TEMPERATURE	19 DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.03
ECSS OPERATING ENERGY	0.000 GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.000 GIGA JOULES
TOTAL ENERGY CONSUMED	0.000 GIGA JOULES

SUBSYSTEM SUMMARY:					
	HOT	WATER	HEATING	COOLING	SYSTEM TOTAL
LCAD		1.767 *	N.A.	N.A.	1.767 GIGA JOULES
SOLAR FRACTION USED		*	N.A.	N.A.	* PERCENT
SOLAR ENERGY USED		0.052	N.A.	N.A.	0.052 GIGA JOULES
OPERATING ENERGY		N.A.	N.A.	N.A.	0.000 GIGA JOULES
AUX. THERMAL ENG		*	N.A.	N.A.	* GIGA JOULES
AUX. ELECTRIC FUEL		N.A.	N.A.	N.A.	N.A. GIGA JOULES
AUX. FOSSIL FUEL		*	N.A.	N.A.	* GIGA JOULES
ELECTRICAL SAVINGS		N.A.	N.A.	N.A.	0.000 GIGA JOULES
FOSSIL SAVINGS		0.086	N.A.	N.A.	0.086 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: *

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978,
SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SOLAR/1046-79/03

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA
REPORT PERIOD: MARCH, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LCADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.093	47	0.001	NOT	0.000	APPLICABLE	0.012
2	0.026	47	0.002		0.000		0.068
3	0.011	49	0.001		0.000		0.072
4	0.078	52	0.003	APPLICABLE	0.000		0.032
5	0.065	57	0.001		0.000		0.017
6	0.082	61	0.002		0.000		0.024
7	0.076	61	0.002		0.000		0.023
8	0.086	62	0.002		0.000		0.026
9	0.085	60	0.002		0.000		0.028
10	0.039	55	0.001		0.000		0.027
11	0.047	56	0.003		0.000		0.058
12	0.061	59	0.002		0.000		0.032
13	0.076	58	0.002		0.000		0.021
14	0.018	54	0.001		0.000		0.078
15	0.010	52	0.001		0.000		0.093
16	0.010	47	0.001		0.000		0.151
17	0.057	52	0.002		0.000		0.028
18	0.060	52	0.002		0.000		0.035
19	0.091	54	0.001		0.000		0.015
20	0.076	53	0.002		0.000		0.018
21	0.088	52	0.001		0.000		0.017
22	0.028	53	0.001		0.000		0.048
23	0.079	55	0.001		0.000		0.014
24	0.088	57	0.002		0.000		0.021
25	0.080	55	0.002		0.000		0.020
26	0.004	52	0.002		0.000		0.428
27	0.030	53	0.002		0.000		0.057
28	0.056	52	0.001		0.000		0.024
29	0.080	52	0.001		0.000		0.014
30	0.083	51	0.001		0.000		0.014
31	0.083	53	0.001		0.000		0.017
SUM	1.846	-	0.049	N.A.	0.000	N.A.	-
AVG	0.060	54	0.002	N.A.	0.000	N.A.	0.027
NBS ID	0001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.

‡ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT COLLECTOR ARRAY PERFORMANCE

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/03
REPORT PERIOD: MARCH, 1979

DAY OF MONT	INCIDENT SOLAR ENERGY MILLICN BTU	OPERATIONAL INCIDENT ENERGY MILLICN BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.093	0.000	0.000	56	0.000
2	0.026	0.000	0.000	54	0.000
3	0.011	0.000	0.000	52	0.000
4	0.078	0.000	0.000	62	0.000
5	0.065	0.000	0.000	67	0.000
6	0.082	0.000	0.000	71	0.000
7	0.076	0.000	0.000	71	0.000
8	0.086	0.000	0.000	72	0.000
9	0.085	0.000	0.000	74	0.000
10	0.039	0.000	0.000	*	0.000
11	0.047	0.000	0.000	66	0.000
12	0.061	0.000	0.000	67	0.000
13	0.076	0.000	0.000	66	0.000
14	0.018	0.000	0.000	60	0.000
15	0.010	0.000	0.000	56	0.000
16	0.010	0.000	0.000	51	0.000
17	0.057	0.000	0.000	58	0.000
18	0.060	0.000	0.000	61	0.000
19	0.091	0.000	0.000	64	0.000
20	0.076	0.000	0.000	63	0.000
21	0.088	0.000	0.000	60	0.000
22	0.028	0.000	0.000	58	0.000
23	0.079	0.000	0.000	67	0.000
24	0.088	0.000	0.000	70	0.000
25	0.080	0.000	0.000	68	0.000
26	0.004	0.000	0.000	54	0.000
27	0.030	0.000	0.000	56	0.000
28	0.056	0.000	0.000	59	0.000
29	0.080	0.000	0.000	62	0.000
30	0.083	0.000	0.000	60	0.000
31	0.083	0.000	0.000	*	0.000
SUM	1.846	0.000	0.000	-	-
AVG	0.060	0.000	0.000	62	0.000
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT STORAGE PERFORMANCE

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/03
 REPCRT PERIOD: MARCH, 1979

DAY OF MONTH	ENERGY TC STORAGE MILLICN BTU	ENERGY FROM STORAGE MILLICN BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.000	0.001	NOT	NOT	NOT
2	0.000	0.001	NOT	NOT	NOT
3	0.000	0.000	NOT	NOT	NOT
4	0.000	0.001	NOT	NOT	NOT
5	0.000	0.001	NOT	NOT	NOT
6	0.000	0.001	NOT	NOT	NOT
7	0.000	0.001	NOT	NOT	NOT
8	0.000	0.002	NOT	NOT	NOT
9	0.000	0.002	NOT	NOT	NOT
10	0.000	0.000	NOT	NOT	NOT
11	0.000	0.002	NOT	NOT	NOT
12	0.000	0.001	NOT	NOT	NOT
13	0.000	0.001	NOT	NOT	NOT
14	0.000	0.001	NOT	NOT	NOT
15	0.000	0.000	NOT	NOT	NOT
16	0.000	0.001	NOT	NOT	NOT
17	0.000	0.001	NOT	NOT	NOT
18	0.000	0.001	NOT	NOT	NOT
19	0.000	0.001	NOT	NOT	NOT
20	0.000	0.001	NOT	NOT	NOT
21	0.000	0.001	NOT	NOT	NOT
22	0.000	0.001	NOT	NOT	NOT
23	0.000	0.001	NOT	NOT	NOT
24	0.000	0.001	NOT	NOT	NOT
25	0.000	0.001	NOT	NOT	NOT
26	0.000	0.001	NOT	NOT	NOT
27	0.000	0.001	NOT	NOT	NOT
28	0.000	0.001	NOT	NOT	NOT
29	0.000	0.001	NOT	NOT	NOT
30	0.000	0.001	NOT	NOT	NOT
31	0.000	0.001	NOT	NOT	NOT
SUM	0.000	0.030	N.A.	-	-
AVG	0.000	0.001	N.A.	N.A.	N.A.
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT HOT WATER SUBSYSTEM

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA
REPORT PERIOD: MARCH, 1979
SOLAR/1046-79/03

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.CF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FGSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.046	4	0.001		0.051		0.085		0.002	62	117	100
2	0.052	6	0.002		0.055		0.092		0.003	61	103	137
3	0.040	7	0.001		0.052		0.086		0.001	63	120	134
4	0.077	*	0.003		*		*		0.004	62	126	160
5	0.036	*	0.001		*		*		0.002	63	125	170
6	0.054	*	0.002		*		*		0.003	65	124	126
7	0.043	*	0.002		*		*		0.003	63	124	81
8	0.067	*	0.002		*		*		0.004	63	113	163
9	0.066	*	0.002		*		*		0.004	65	112	163
10	0.053	*	0.001		*		*		0.002	67	134	95
11	0.070	*	0.003		*		*		0.005	66	123	156
12	0.059	*	0.002		*		*		0.003	65	127	120
13	0.053	*	0.002		*		*		0.003	65	123	118
14	0.042	*	0.001		*		*		0.002	65	126	87
15	0.049	*	0.001		*		*		0.002	65	130	98
16	0.043	*	0.001		*		*		0.002	66	131	100
17	0.054	*	0.002		*		*		0.003	65	126	106
18	0.097	*	0.002		*		*		0.004	64	122	220
19	0.040	*	0.001		*		*		0.002	65	125	75
20	0.047	*	0.001		*		*		0.002	66	134	88
21	0.042	*	0.002		*		*		0.003	64	118	115
22	0.051	*	0.001		*		*		0.002	64	119	114
23	0.050	*	0.001		*		*		0.002	65	126	100
24	0.048	*	0.002		*		*		0.003	65	125	93
25	0.069	*	0.002		*		*		0.003	65	123	110
26	0.081	*	0.002		*		*		0.003	66	125	131
27	0.053	*	0.001		*		*		0.003	66	124	165
28	0.043	*	0.001		*		*		0.002	65	127	102
29	0.041	*	0.001		*		*		0.002	64	120	102
30	0.041	*	0.001		*		*		0.002	65	126	95
31	0.060	*	0.001		*		*		0.002	64	129	114
SUM	1.675	-	0.049	N.A.	*	N.A.	*	N.A.	0.082	-	-	3606
AVG	0.054	*	0.002	N.A.	*	N.A.	*	N.A.	0.003	64	123	116
NBS	Q302	N300	Q300	Q303	G301	Q305	Q306	G311	G313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT ENVIRONMENTAL SUMMARY

SITE: LIVING SYSTEMS (159-1) DAVIS, CALIFORNIA SOLAR/1046-79/03
REPORT PERIOD: MARCH, 1979

DAY OF MONTH	TOTAL INSCLATCN BTU/SQ.FT	DIFFUSE INSCLATCN BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	2025	NCT APPLICABLE	47	56	70	221	3
2	575		47	54	73	0	1
3	229		49	52	91	203	4
4	1701		52	62	83	0	2
5	1407		57	67	84	195	2
6	1790		61	71	80	0	2
7	1651		62	71	85	191	3
8	1874		60	72	75	205	3
9	1847		55	74	80	339	4
10	838		56	*	88	327	4
11	1030		56	66	82	0	2
12	1318		59	67	82	*	3
13	1659		58	66	80	318	7
14	394		54	60	77	341	5
15	219		52	56	85	355	5
16	215		47	51	89	14	6
17	1230		52	58	81	286	5
18	1302		52	61	74	330	4
19	1970		54	64	73	*	3
20	1648		53	63	78	79	8
21	1918		52	60	77	343	4
22	617		53	58	80	*	4
23	1726		55	67	71	219	2
24	1912		57	70	63	326	3
25	1730		55	68	68	350	4
26	83		52	54	87	15	10
27	657		53	56	88	3	15
28	1209		52	59	77	41	4
29	1749		52	59	73	353	8
30	1806		52	62	71	218	5
31	1808		51	60	60	224	6
SUM	40137	N.A.	-	-	-	-	-
AVG	1295	N.A.	54	62	78	338	5
NBS ID	G001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

SCLAR HEATING AND COCLING DEMONSTRATION PROGRAM

MONTHLY REPORT SITE SUMMARY

SITE: LIVING SYSTEMS (159-2)
REPORT PERIOD: MARCH, 1979

DAVIS, CALIFORNIA

SOLAR/1046-79/03

SITE/SYSTEM DESCRIPTION:

THE LIVING SYSTEMS PASSIVE SCLAR SPACE HEATING SYSTEM PROVIDES SPACE HEATING FOR A 1700 SQUARE FOOT SINGLE FAMILY DWELLING. THE LARGE SOUTH-FACING WINDOW WALL AND CLERESTORY SKYLIGHT PERMIT DIRECT WINTER SUN TO ENTER THE HOUSE. SOLAR ENERGY THERMAL STORAGE IS PROVIDED BY BOTH WATER FILLED TUBES AND THE CONCRETE SLAB FLOOR. MOVABLE SHUTTERS AND INSULATING CURTAINS PROVIDE CAPABILITY TO REDUCE NIGHT HEAT LOSSES. SUMMER OVERHEAT PROTECTION IS PROVIDED BY ROOF OVERHANGS AND BY NATURAL VENTILATION. AUXILIARY SPACE HEAT IS PROVIDED BY A NATURAL GAS FURNACE.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY

COLLECTED SOLAR ENERGY

AVERAGE AMBIENT TEMPERATURE
AVERAGE BUILDING TEMPERATURE
ECSS SOLAR CONVERSION EFFICIENCY
ECSS OPERATING ENERGY
TOTAL SYSTEM OPERATING ENERGY
TOTAL ENERGY CONSUMED

10.104 MILLION BTU
37012 BTU/SQ.FT.
4.119 MILLION BTU
15202 BTU/SQ.FT.
54 DEGREES F
67 DEGREES F
0.40
N.A. MILLION BTU
N.A. MILLION BTU
4.092 MILLION BTU

SUBSYSTEM SUMMARY:

LOAD
SOLAR FRACTION USED
SOLAR ENERGY USED
OPERATING ENERGY
AUX. THERMAL ENERGY
AUX. ELECTRIC FUEL
AUX. FOSSIL FUEL
ELECTRICAL SAVINGS
FOSSIL SAVINGS

HEATING
4.026
99
4.005
N.A.
0.020
N.A.
0.087
N.A.
6.676

COOLING
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.

SYSTEM TOTAL
4.026 MILLION BTU
99 PERCENT
4.005 MILLION BTU
N.A. MILLION BTU
0.020 MILLION BTU
N.A. MILLION BTU
0.087 MILLION BTU
N.A. MILLION BTU
6.676 MILLION BTU

SYSTEM PERFORMANCE FACTOR:

46.273

- * DENOTES UNAVAILABLE DATA
- @ DENOTES NULL DATA
- N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT
OF THE NATIONAL SCLAR DATA PROGRAM, FEBRUARY 28, 1978,
SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT SITE SUMMARY

SITE: LIVING SYSTEMS (159-2) CAVIS, CALIFORNIA
REPORT PERIOD: MARCH, 1979

SOLAR/1046-79/03

SITE/SYSTEM DESCRIPTION:

THE LIVING SYSTEMS PASSIVE SOLAR SPACE HEATING SYSTEM PROVIDES SPACE HEATING FOR A 1700 SQUARE FOOT SINGLE FAMILY DWELLING. THE LARGE SOUTH-FACING WINDOW WALL AND CLERESTORY SKYLIGHT PERMIT DIRECT WINTER SUN TO ENTER THE HOUSE. SOLAR ENERGY THERMAL STORAGE IS PROVIDED BY BOTH WATER FILLED TUBES AND THE CONCRETE SLAB FLOOR. MOVABLE SHUTTERS AND INSULATING CURTAINS PROVIDE CAPABILITY TO REDUCE NIGHT HEAT LOSSES. SUMMER OVERHEAT PROTECTION IS PROVIDED BY ROOF OVERHANGS AND BY NATURAL VENTILATION. AUXILIARY SPACE HEAT IS PROVIDED BY A NATURAL GAS FURNACE.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	10.660	GIGA JOULES
COLLECTED SOLAR ENERGY	420310	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	5.964	GIGA JOULES
AVERAGE BUILDING TEMPERATURE	172635	KJ/SQ.M.
ECSS SOLAR CONVERSION EFFICIENCY	12	DEGREES C
ECSS OPERATING ENERGY	19	DEGREES C
TOTAL SYSTEM OPERATING ENERGY	0.40	GIGA JOULES
TOTAL ENERGY CONSUMED	N.A.	GIGA JOULES
	N.A.	GIGA JOULES
	4.317	GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING
LOAD	N.A.	4.247	N.A.
SOLAR FRACTION	N.A.	99	N.A.
SOLAR ENERGY USED	N.A.	4.226	N.A.
OPERATING ENERGY	N.A.	N.A.	N.A.
AUX. THERMAL ENG	N.A.	0.021	N.A.
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.
AUX. FOSSIL FUEL	N.A.	0.092	N.A.
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.
FOSSIL SAVINGS	N.A.	7.043	N.A.

SYSTEM PERFORMANCE FACTOR:

46.273

* DENOTES UNAVAILABLE DATA

@ DENOTES NULL DATA

N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978,
SCLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT COLLECTOR ARRAY PERFORMANCE

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/03
 REPORT PERIOD: MARCH, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.541	0.160	NOT	56	NOT
2	0.141	0.033		54	
3	0.048	0.006		52	
4	0.453	0.247	APPLICABLE	62	APPLICABLE
5	0.368	0.069		67	
6	0.472	0.351		71	
7	0.425	0.227		71	
8	0.487	0.357		72	
9	0.478	0.358		74	
10	0.210	0.128		*	
11	0.260	0.122		66	
12	0.333	0.078		67	
13	0.425	0.040		66	
14	0.091	0.000	APPLICABLE	60	APPLICABLE
15	0.048	0.000		56	
16	0.045	0.005		51	
17	0.303	0.083		58	
18	0.326	0.190		61	
19	0.458	0.254		64	
20	0.417	0.119		63	
21	0.483	0.113		60	
22	0.147	0.019		58	
23	0.435	0.102		67	
24	0.476	0.173		70	
25	0.434	0.137		68	
26	0.014	0.003		54	
27	0.163	0.038		56	
28	0.289	0.000		59	
29	0.421	0.216		62	
30	0.439	0.000		60	
31	0.434	0.194		*	
SUM	10.104	3.822	4.119	-	-
AVG	0.326	0.123	N.A.	62	N.A.
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SOLAR/1046-79/03

DAVIS, CALIFORNIA

SITE: LIVING SYSTEMS (159-2)
REPORT PERIOD: MARCH, 1979

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR. OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.167	99	0.165	N C T	0.002	N O T	0.014	N O T	0.276	63	47
2	0.137	88	0.120		0.017		0.046		0.200	62	47
3	0.064	97	0.062		0.002		0.017		0.104	64	49
4	0.122	100	0.122		0.000		0.010		0.204	64	52
5	0.079	100	0.079		0.000		0.000		0.131	66	57
6	0.081	100	0.081		0.000		0.000		0.135	69	61
7	0.092	100	0.092		0.000		0.000		0.153	70	61
8	0.098	100	0.098		0.000		0.001		0.163	71	62
9	0.145	100	0.145		0.000		0.000		0.242	72	60
10	0.156	100	0.156		0.000		0.000		0.260	69	55
11	0.127	100	0.127		0.000		0.000		0.212	69	56
12	0.101	100	0.101		0.000		0.000		0.168	69	59
13	0.125	100	0.125		0.000		0.000		0.208	70	58
14	0.131	100	0.131		0.000		0.000		0.218	67	54
15	0.140	100	0.140		0.000		0.000		0.233	66	52
16	0.163	100	0.163		0.000		0.000		0.271	64	47
17	0.119	100	0.119		0.000		0.000		0.198	66	52
18	0.160	100	0.160		0.000		0.000		0.267	67	54
19	0.145	100	0.145		0.000		0.000		0.242	67	54
20	0.153	100	0.153		0.000		0.000		0.254	67	53
21	0.184	100	0.184		0.000		0.000		0.307	67	52
22	0.118	100	0.118		0.000		0.000		0.196	66	53
23	0.080	100	0.080		0.000		0.000		0.134	68	55
24	0.108	100	0.108		0.000		0.000		0.180	68	57
25	0.137	100	0.137		0.000		0.000		0.229	68	55
26	0.167	100	0.167		0.000		0.000		0.279	66	52
27	0.174	100	0.174		0.000		0.000		0.289	65	53
28	0.129	100	0.129		0.000		0.000		0.214	65	52
29	0.159	100	0.159		0.000		0.000		0.266	66	52
30	0.149	100	0.149		0.000		0.000		0.248	65	51
31	0.118	100	0.118		0.000		0.000		0.196	65	53
SUM	4.026	-	4.005	N.A.	0.020	N.A.	0.087	N.A.	6.676	-	-
AVG	0.130	99	0.129	N.A.	0.001	N.A.	0.003	N.A.	0.215	67	54
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT ENVIRONMENTAL SUMMARY

SOLAR/1046-79/03

DAVIS, CALIFORNIA

SITE: LIVING SYSTEMS (159-2)
REPORT PERIOD: MARCH, 1979

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	1980	N	47	56	70	221	3
2	516	C	47	54	73	0	1
3	177	T	49	52	91	203	4
4	1660		52	62	83	0	2
5	1348	A	57	67	84	195	2
6	1729	P	61	71	80	0	2
7	1556	P	61	71	85	191	3
8	1783	L	62	72	75	205	2
9	1750	I	60	74	80	339	4
10	769	C	55	66	88	327	4
11	953	A	56	66	82	0	2
12	1219	C	59	67	82	*	2
13	1556	A	58	66	80	318	7
14	333	E	54	60	85	341	5
15	177		52	56	77	355	6
16	165		47	51	89	14	5
17	1110		52	58	81	286	5
18	1194		52	61	74	330	4
19	1825		54	64	73	*	3
20	1528		53	63	78	79	8
21	1769		52	60	77	343	4
22	539		53	58	80	*	2
23	1594		55	67	71	219	4
24	1743		57	70	63	326	3
25	1589		55	68	68	350	4
26	52		52	54	87	15	10
27	598		53	56	88	3	15
28	1059		52	59	77	41	4
29	1541		52	62	73	353	8
30	1608		51	60	71	218	5
31	1591		53	60	60	224	6
SUM	37012	N.A.	-	-	-	-	-
AVG	1194	N.A.	54	62	78	338	5
NBS ID	0001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT PASSIVE SPACE HEATING

SITE: LIVING SYSTEMS (159-2) DAVIS, CALIFORNIA SOLAR/1046-79/03
REPORT PERIOD: MARCH, 1979

DAY OF MO	SPACE HEATING LOAD MILLION BTU	SOLAR ENERGY USED MILLION BTU	CHANGE IN STORE ENERGY MILLION BTU	AVERAGE STORAGE TEMP DEG F	DIRECT SOLAR UTIL EFFIC	AUX THERMAL USED MILLION BTU	BLDG TEMP DEG F	AMB TEMP DEG F	WIND AVG SPEED MPH	WIND DIR DEG	SOLA FR LOAD PER CENT
1	0.166	0.165	0.029	65.0	0.306	0.001	63	47	3.1	221	99
2	0.136	0.119	-0.025	64.7	0.851	0.016	62	47	0.8	0	88
3	0.064	0.062	-0.012	65.6	1.288	0.002	64	49	3.7	203	97
4	0.122	0.122	0.070	65.4	0.270	0.000	66	52	1.8	0	100
5	0.078	0.078	0.061	66.2	0.213	0.000	66	57	2.4	195	100
6	0.080	0.080	0.185	68.4	0.217	0.000	69	61	1.8	0	100
7	0.092	0.092	0.082	70.1	0.201	0.000	70	61	2.5	191	100
8	0.097	0.097	0.098	71.8	0.304	0.000	71	62	3.5	205	100
9	0.145	0.145	0.077	73.0	0.342	0.000	72	60	3.7	339	100
10	0.155	0.155	-0.109	72.3	0.489	0.000	69	55	4.0	327	100
11	0.127	0.127	-0.057	71.0	0.303	0.000	69	56	1.7	0	100
12	0.100	0.100	-0.019	70.1	0.294	0.000	69	59	2.5	*	100
13	0.124	0.124	-0.015	69.8	1.442	0.000	70	58	6.7	318	100
14	0.130	0.130	-0.080	69.0	2.886	0.000	67	54	5.0	341	100
15	0.139	0.139	-0.073	68.0	3.604	0.000	66	52	5.0	355	100
16	0.162	0.162	-0.071	66.5	0.392	0.000	64	47	6.0	14	100
17	0.118	0.118	0.056	67.9	0.492	0.000	66	52	5.2	286	100
18	0.160	0.160	0.022	68.1	0.292	0.000	67	52	4.0	330	100
19	0.145	0.145	0.070	68.7	0.366	0.000	67	54	4.0	79	100
20	0.152	0.152	-0.006	68.9	0.381	0.000	67	53	3.1	343	100
21	0.183	0.183	-0.037	69.0	0.799	0.000	66	53	3.5	*	100
22	0.117	0.117	0.038	68.1	0.184	0.000	68	55	2.2	219	100
23	0.080	0.080	0.058	69.2	0.227	0.000	68	57	2.9	326	100
24	0.107	0.107	0.011	69.4	0.317	0.000	68	55	4.2	350	100
25	0.137	0.137	-0.102	69.0	11.834	0.000	66	52	10.2	15	100
26	0.167	0.167	-0.068	68.1	1.064	0.000	66	53	15.3	3	100
27	0.173	0.173	-0.014	66.6	0.445	0.000	65	53	4.4	41	100
28	0.128	0.128	-0.014	66.1	0.379	0.000	65	52	7.7	353	100
29	0.159	0.159	-0.024	66.2	0.339	0.000	65	51	4.7	218	100
30	0.148	0.148	-0.030	66.0	3.271	0.000	65	53	5.8	224	100
31	0.117	0.117	0.028	66.0	-	-	-	-	-	-	-
SUM	4.025	4.005	0.144	-	-	0.020	-	-	-	-	-
AVG	0.129	0.129	0.004	68.2	0.396	0.000	67	54	4.5	338	99
NBS	Q402	Q400	Q202	-	-	Q401	N405	N113	N114	N115	N400

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT PASSIVE SYSTEM ENVIRONMENT

SOLAR/1046-79/03

DAVIS, CALIFORNIA

SITE: LIVING SYSTEMS (159-2)
REPORT PERIOD: MARCH, 1979

DAY OF MO	BUILDING COMFORT ZONE 1	BLDG COMF ZONE 2	BUILDING TEMP MIDNIGHT DEG F	BUILDING TEMP 6 AM DEG F	BUILDING TEMP NOON DEG F	BUILDING TEMP 6 PM DEG F	INTERIOR RELATIVE HUMIDITY PERCENT	AMB TEMP DEG F	DAYTIME AMB TEMP DEG F	INCIDENT SOLAR ENERGY MILLION BTU	AVG STOR TEMP DEG F
1	65	65	63	60	65	67	42	47	56	0.541	65
2	65	64	64	59	63	64	40	47	54	0.141	65
3	66	65	61	63	63	64	43	49	52	0.048	66
4	66	65	66	59	65	68	43	52	62	0.453	65
5	67	67	67	63	66	69	47	57	67	0.368	66
6	70	69	71	64	69	74	48	61	71	0.472	68
7	71	71	71	67	70	75	50	61	71	0.425	70
8	72	72	71	68	71	75	47	62	72	0.487	72
9	73	73	72	67	73	77	45	60	74	0.478	73
10	71	72	69	68	68	71	46	55	*	0.210	72
11	71	71	69	66	69	69	45	56	66	0.260	71
12	70	70	71	65	68	73	47	59	67	0.333	70
13	69	69	68	65	70	71	45	58	60	0.425	69
14	68	68	67	65	67	68	46	54	56	0.091	68
15	66	66	65	66	66	67	44	52	51	0.048	67
16	68	67	65	63	63	63	44	47	51	0.045	68
17	68	67	67	64	66	69	43	52	58	0.326	68
18	69	68	67	64	68	71	43	54	61	0.498	69
19	69	65	67	63	67	71	43	53	63	0.417	69
20	69	68	66	64	68	70	42	53	60	0.483	69
21	68	67	66	64	65	67	43	53	58	0.147	68
22	70	68	66	64	69	71	42	55	67	0.435	69
23	69	69	67	64	70	70	39	57	70	0.476	69
24	69	69	68	64	69	69	39	55	68	0.434	69
25	67	68	65	65	66	66	42	52	54	0.014	68
26	66	67	65	64	64	66	46	53	56	0.163	67
27	66	66	64	63	65	66	47	52	59	0.289	66
28	67	67	64	63	65	67	43	52	62	0.421	66
29	66	66	65	62	64	67	42	51	60	0.439	66
30	66	66	66	61	66	69	38	53	*	0.434	66
31	66	66	66	61	66	69	38	53	*	0.434	66
SUM	-	-	-	-	-	-	-	-	-	10.104	-
AVG	68	68	67	64	67	69	44	54	62	0.326	68
NBS	-	-	-	-	-	-	-	N113	-	-	-

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

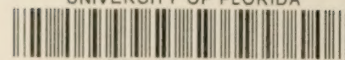
N.A. DENOTES NOT APPLICABLE DATA.

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3 1262 09052 5501